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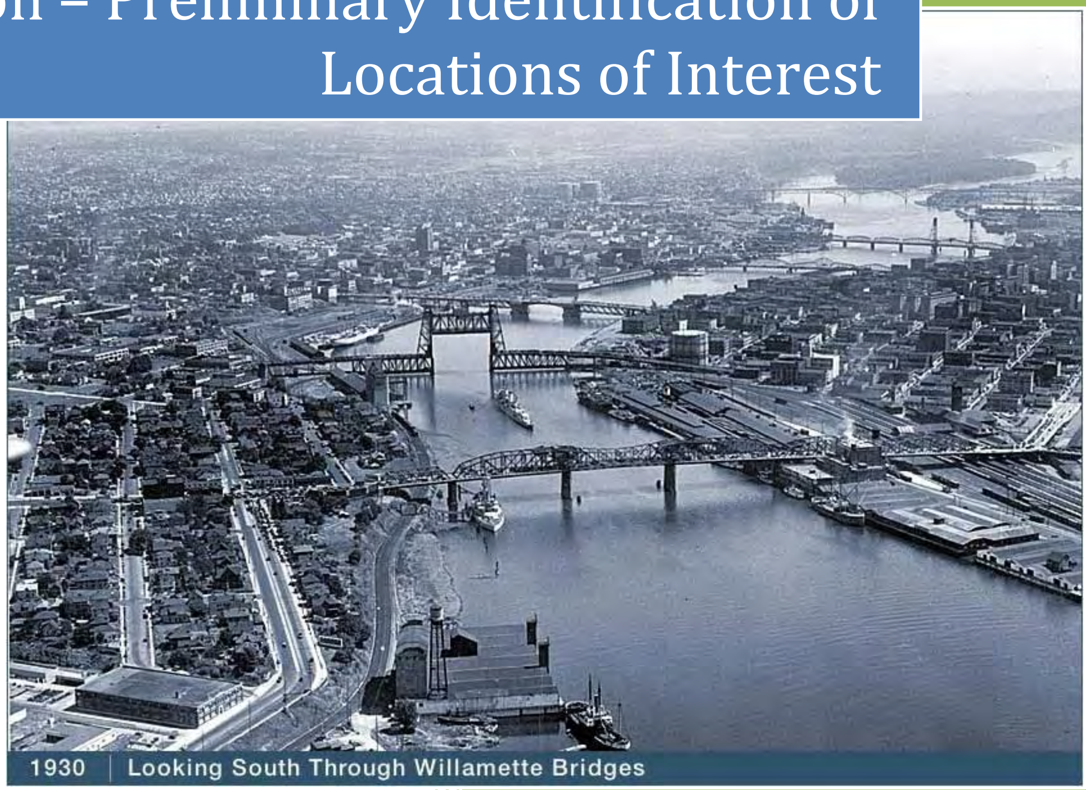
Downtown Portland – Willamette River Sediment Evaluation – Preliminary Identification of Locations of Interest



State of Oregon Department of Environmental Quality

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Acronyms

DDT	Dichlorodiphenyltrichloroethane
DPSC	Downtown Portland Sediment Characterization
DEQ	Department of Environmental Quality
GCMS	Gas Chromatography Mass Spectroscopy
HI	Hazard Index
MOU	Memorandum of Understanding
OF	Outfall
OMSI	Oregon Museum of Science and Industry
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated biphyenyls
PCP	Pentachlorophenol
PH	Portland Harbor
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
SL	Screening Level
SLV	Screening Level Value
TCDD	Tetrachlorodibenzo-*p*-Dioxin

Downtown Portland Willamette River Sediment Evaluation –

Preliminary Identification of Locations of Interest

1.0 Objectives

The purpose of this document is to describe the initial evaluation of the sediment data collected in the downtown reach of the Willamette River (approximately from the Steel Bridge to Ross Island) to locate and describe areas, where additional investigation and source identification efforts appear to be warranted. It is not intended to represent an area-wide risk assessment of this section of the river; rather it is focused on identifying areas where contaminant concentrations suggest a potential risk that warrants follow-up. The next phase of activity (Phase II sampling) is designed to confirm and refine our initial assessment of the magnitude of contamination in the identified areas. Based on the information obtained from this second phase of sampling, the need for additional efforts to identify sources and evaluate cleanup actions will be evaluated. It is anticipated that this next phase of sample collection will occur in the in the fall of 2009 and a field and data report will be issued in early 2010.

Subsequent assessment of the data, provided in the field and data report, will be undertaken to:

- Assess a background sediment concentration range of contaminants of potential concern based on a screening level risk evaluation.
- Further characterize the extent of contamination at locations where ambient and risk-based concentrations are exceeded.
- Evaluate whether sediment in the downtown reach poses a recontamination threat to the Portland Harbor Study area (consistent with DEQ's role as lead agency for source control in the Portland Harbor Memorandum of Understanding (MOU)).
- Develop a strategy to remediate any identified hot spots of contaminated sediment and reduce the overall footprint of contamination in sediment.

A more detailed risk assessment evaluation will occur as resources and priorities dictate.

2.0 Background

In the summer of 2008, a collaborative effort by the Oregon Department of Environmental Quality (DEQ), the City of Portland (City), ZRZ Realty Company, Portland General Electric, PacifiCorp, and TriMet was initiated to assess the potential presence of environmental contaminants in sediment within the downtown Portland reach of the Willamette River from River Mile 12 to 16. Eighty-one (81) surface and 36 subsurface samples were successfully collected and analyzed and the results provided in a *Field and Data Report (GSI Water Solutions,* *Inc. 2009)* submitted to DEQ in January 2009. The process of collecting and analyzing the samples is thoroughly described in the GSI Report.

The purpose of the investigation was to gain a better understanding of the nature and extent of hazardous substances in Willamette River sediments between River Miles (RM) 12 and 16.

Sampling locations were chosen to meet the following objectives:

- Assess the potential impact of stormwater discharge to river sediments.
- Assess the potential impact of past and current riverfront industries on river sediments.
- Assess ambient levels of hazardous substances.

3.0 General Observations

In general, average contaminant concentrations detected in the downtown reach of the Willamette River were lower than concentrations detected in the downstream Portland Harbor reach. In the prioritization process described in the sections that follow, a subset of contaminants reflecting key potential risk drivers were identified.

A comparison of the maximum, average and 95th percentile concentrations for these compounds in the downtown reach to Portland Harbor is presented in Table 1 and illustrated in Figures 1 and 2. The comparison indicates that concentrations are notably higher in Portland Harbor than in the downtown reach for PAHs, total PCB Aroclors, TBT, pesticides, and dioxins/furans. This observation appears to be more pronounced for subsurface sediments which may reflect the more depositional nature of the Portland Harbor environment where historical sources have been partially covered with less contaminated sediment originating from up river. These observations are less clear for arsenic, lead, mercury, and pentachlorophenol; although, arsenic and pentachlorophenol are notably higher in Portland Harbor subsurface sediment than in downtown reach subsurface sediment. A more rigorous statistical comparison of Portland Harbor to the downtown reach is expected to be provided in the Portland Harbor Superfund site Draft Remedial Investigation Report which will be submitted to the U.S. Environmental Protection Agency and DEQ in late October.

While the contaminant concentrations in the downtown reach are generally lower than the Portland Harbor there remain locations that have high enough concentrations to warrant some additional evaluation and potential cleanup. The following sections summarize the evaluation process completed to identify the areas of highest priority for follow-up evaluation.

4.0 Preliminary Evaluation

Sediment samples collected in the downtown Portland sediment characterization (DPSC) were analyzed for a broad range of parameters including: metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), phenols, pesticides, and butyltins. A subset of the samples was also analyzed for dioxins/furans.

A preliminary evaluation was conducted to identify locations with the highest exceedances of conservative risk-based screening levels where additional sampling may be warranted to confirm the detection, focus source identification efforts, and, as feasible, begin to scope the extent of contamination. These locations are referred to as "priority locations." Screening level values (SLVs) used in this evaluation are consistent with the values developed for the Portland Harbor Joint Source Control Strategy (ODEQ, 2005). Because one of the objectives of this evaluation was to identify areas where additional site characterization work should be conducted, it was limited to a relative prioritization of sample sites based on exceedances of SLVs. A more complete risk assessment on this segment of the Willamette may be conducted in the future; remedial investigation and risk assessment work will proceed on a more focused basis in those areas identified in the preliminary assessment for follow-up.

This preliminary evaluation was based on the following data and considerations:

1) Total PCBs – individual Arochlors and congeners were not considered separately.
2) Total DDTs – degradation products were not considered separately.
3) Compounds without established screening levels were not considered.
4) Dioxins/Furans were not included in the initial evaluation but were considered in selecting sampling locations and analyzing archived samples – see discussion below.
5) Compounds that were not detected were excluded from the evaluation.

The list of compounds for which SLVs have been established is substantial and includes representative compounds for all classes of parameters analyzed in this investigation. The compounds evaluated and the associated SLVs are shown in Table 2.

To identify samples with the greatest combined exceedances of risk-based criteria, an evaluation similar to what is completed in a risk assessment for non-carcinogenic impacts (e.g., Hazard Index (HI) calculation) was conducted. The concentration detected was divided by the appropriate SLV for all sample results.

$$HI = Conc_x/SLV_x \qquad (1)$$

Where $Conc_x$ = the concentration of contaminant x detected in the sample, and
SLV_x = lowest SLV for contaminant x

To derive an overall ranking for the sample these ratios were added together.

$$\text{Overall } HI = HI_x + HI_y + HI_z \text{ etc} \qquad (2)$$

Where $HI_{x,y,z}$ = the HI values for each compound detected in the sample for which a SLV was available.

It should be noted that this evaluation combines HI values that are not considered additive and calculates HI ratios for carcinogenic compounds. For example, the lowest (i.e., most conservative) applicable SLV was used for comparison, resulting in some SLVs reflecting potential bioaccumulation risk and some reflecting potential toxicity risks. In this way, the samples with the cumulative greatest exceedances of risk based criteria were identified. Because the bioaccumulation SLVs are typically much lower than toxicity-based SLVs, samples in which bioaccumulative contaminants were detected were generally identified as the samples of greatest concern. To ensure that toxicity issues were also adequately considered a second screen was completed (discussed below) that utilized toxicity SLVs only. Also, as discussed below, dioxin compounds were not included in the initial evaluation as they were not analyzed in all samples.

The resulting values for the sum of the ratios of concentration detected to SLVs for each sample location is presented in Table 3. As discussed further in Section 5, the majority of locations identified for follow-up investigation are driven by bioaccumulation impacts associated with PCBs and to a lesser extent DDT.

Potential bioaccumulation risks are also posed by the concentrations of dioxins/furans detected in some samples. Dioxins were not included in the initial HI evaluation because they were not analyzed in every sample and, because the SLV is so low, they would drive the priority wherever they were detected. To include them in the HI calculations would therefore be misleading, as it is likely dioxins were present in samples in which they were not analyzed. Consequently, they were considered separately. Dioxins were analyzed in 73 of the samples collected and detected in 36 of those. The highest concentration of 2,3,7,8 TCDD (the dioxin congener with the lowest bioaccumulation-based screening level) was 5.6×10^{-7} mg/kg (HH SLV = 9.1×10^{-9}) in sample C022. The highest dioxin toxicity equivalency quotients (TEQs) were calculated for dioxin/furan concentrations detected in samples G030, G045, and C007. While dioxin/furan concentrations were not included in the initial ranking of sites, the locations identified as having the highest potential risk based on these compounds were already identified as a priority for follow-up based on the initial analysis or were located in proximity to those samples. The locations are highlighted in the Section 5 discussions of priority areas for follow-up and dioxin will be considered a contaminant of potential concern in those areas.

As indicated above, the initial evaluation of potential risk was driven by potential for bioaccumulation of contaminants and associated risk up the food chain. This is due to the fact that bioaccumulation screening levels are so low. However, it is important to consider potential toxicity impacts as well. Exposure pathways and receptors for toxicity are different from those considered for bioaccumulation impacts. Parameters incorporated into risk assessments, such as area use factors, will tend to reduce the significance of isolated high concentration samples for bioaccumulation evaluations, but will not have a similar reduction for the toxicity pathway.

This is due to the fact that benthic organisms are sessile and consequently are exposed to concentrations in a limited area. To address this, a second prioritization of sample locations was completed based on toxicity impacts alone. The same contaminants were considered; however, bioaccumulation SLVs were replaced with the appropriate toxicity SLVs. The sum of ratios using this approach is presented in Table 4. As can be seen in this table, the top 3 sums were notably higher than the next set. As discussed in the following section, these sample locations were also identified for follow-up evaluation.

5.0 Priority area identification

5.1 Results of Calculations

As shown in Figure 3 (and tabulated in Table 3), there are 9 samples that fall into the highest range of HI values. These samples all have cumulative HI ratios that exceed 700. This grouping of sample sites was determined by examining the plot of HI values and looking for discernable trends in the values. The plot notably changes between the top 9 values and the remaining values. The geographic locations of these samples are shown in Figure 4. The plot also indicates that the subsequent 6 HI values are very similar to each other, with cumulative HI ratios in the range of 400 to 500. There is a distinct drop in cumulative HI ratios to the remaining set of values, all of which fall below 300. These 6 samples are identified as a “second tier” of priority. The locations are shown in Figure 5. The tier 2 samples which do not fall into one of the 9 focus areas discussed below may warrant attention in a subsequent follow-up phase, once the evaluation of the nine focus areas has been completed.

The evaluation of cumulative HI ratios using toxicity SLVs only generated a different ranking of sample sites driven by toxicity issues alone. Plotting these HI values from highest to lowest, as shown in Figure 6, reveals three values that stand out as higher than the remaining values. The locations of the three samples with the highest toxicity rank are shown in Figure 7.

DEQ grouped the locations of the top ranked samples considering potential bioaccumulation and toxicity in defining the 9 follow-up areas that are discussed below. It is worth noting that the highest and second highest detections of each of the contaminants are found in one of the areas discussed below.

5.2 Evaluation and Recommendations - Top 9 Ranked Areas

The 9 areas identified for follow-up are described in the sections below. The recommendations for next steps are generally limited to confirming the presence of a release area, assessing the likelihood that it reflects an on-going release, and getting some basic characterization information to support subsequent source identification.

The potential for a current source is assessed primarily based on the presence of surface sediment contamination. Locations where surface concentrations are lower than subsurface concentrations are considered more likely to be associated with historical sources; however, there is some uncertainty in this determination due to the potential for sediment movement that may change conditions over time.

For each identified area, contaminants with the greatest contribution to the cumulative HI are identified and their respective concentrations listed. (The samples responsible for the ranking are highlighted in blue.) Samples collected in proximity to those that had the higher ranking are also identified. Contaminants listed include any which generated an HI ratio greater than 10 in the targeted or surrounding samples.

A brief section is included with each priority area discussion on potential sources of contamination. This information should not be considered an exhaustive evaluation of potential sources. Where Phase 2 data confirm an area of concern, resources will be engaged to initiate the process for fully evaluating likely source areas. Where a stormwater outfall (City or private) is identified as a potential source, site-specific research on system construction, operation, and upland connections will be completed to assess current and historic contributions.

Finally, a section describing recommended next steps is provided. These steps consist of a combination of analyzing archived samples and conducting additional sampling in the targeted area. Split samples from each location and samples of several intervals of sediment cores were archived during the original sampling effort and thus are available for anlaysis. Archived sample analysis will be used to confirm the areas of concern and provide an initial indication of horizontal or vertical trends. Additional sampling will be conducted for these objectives as well and, in some cases, to gain an initial sense of the magnitude and extent of the area of potential concern.

5.2.1 Sample C031 area (Figure 8) RM 12.1E

The majority of potential risk at this location results from the concentrations of total DDTs, Dieldrin, and PCBs. Lead, chlordanes, and dioxins also exceeded SLVs by more than an order of magnitude. The sample reflects a core collected from a depth of 129 to 199 cm below the sediment surface. Surface sediment samples in the vicinity of this core were G065, G064, and G064. None of these samples suggested a more recent release of the contaminants detected at C031 as indicated below:

Sample/Contaminant	Total DDTs (ppb)	Total PCBs (ppb)	Dieldrin (ppb)	Lead (ppm)	Chlordanes(ppb)	TCDD (pg/g) TEQ
SLV	0.33	0.39	0.0081	17	0.37	0.0091
C031 (129 – 199 cm)	300.5	239	7.45	371	8.1	5.04
G063	1.1	6.9	ND (0.1)	21	0.24	NA
G064	2.92	5.7	0.28	23.4	1.24	3.01
G065	5.25	28	ND (0.2)	40.35	ND (0.36)	NA

Potential Sources: There are stormwater outfalls in this area. It is located in the immediate vicinity of City OF 40. It is also the location of a major I-5 highway drainage outfall. Potential sources in the drainage area include a historic warehouse and wharf over the river, railroad switchyard on the bank, wetland drainage from Sullivan Gulch, historic Rose City Plating and extensive truck repair facilities at the Convention center location, historic Sears store, historic paint manufacturer in gulch at 11th, and Benson High School.

Recommendation: Analyze archived A (0 – 30 cm) and B (30 – 129 cm) cores from C031 to determine if there is a more recent release. Analytes should include all contaminants identified in the above table as they were elevated in one or more samples in the area of concern. Confirm pesticide detection in C031-C using high resolution gas chromatography mass spectrum (HR-GCMS) analysis. This is recommended for some select samples to evaluate whether pesticides are actually present or were identified as present due to co-elution effects and resulting difficulty in separating peaks associated with pesticides from those associated with Arochlors in the resulting chromatograms. Collect two surface sediment samples and two cores to assess potential source at OFs 40 and WR309.

5.2.2 Sample G003 (Figure 9) RM 12.4W

This sample was collected on the west bank along the sea wall at SW Pine Street. It had the highest hazard index cumulative score not considering bioaccumulative exposure. PAHs and mercury exceeded SLVs in this sample. No other samples were collected in the immediate vicinity of this location.

Sample/Contaminant	Mercury (ppm)	Indeno(1,2,3-cd)Pyrene (ppb)	Naphthalene (ppb)	Acenaphthene (ppb)
SLV	0.07	100	561	200
G003	4.06	1400	5300	1900

Potential Sources: Possible sources include fuel losses at the sternwheeler dock and historical stormwater discharge from the former Harbor Drive.

Recommendations: Collect a sample for bioassay analysis to determine if additional action is warranted. Analytes of potential concern are identified in the table above and may be analyzed if bioassay results indicate potential toxicity. The investigation in this area should be coordinated with the downstream NW Natural investigation.

5.2.3 Samples G058/G054 Area (Figure 10) RM 12.5E

The majority of potential risk at G058 results from concentrations of Dieldrin and PCBs. DDTs also exceeded SLVs by more than a factor of 10. The closest samples to this location are C030 and G057. C030 is a core sample collected from 30 to 99 cm below sediment surface. The PCB concentration at G057 suggests broader contamination in this area.

The majority of potential risk at G054, located approximately 1000 feet upstream from G058, results from the concentrations of total PCBs with some contribution from total DDTs. Dioxin concentrations were also above the SLV. The only other sample collected in the vicinity of this sample is C028, a core sample collected from 30 to 58 cm below the surface. It contained concentrations of PCBs and DDTs as well as lead and mercury exceeding SLVs by more than an order of magnitude. Lead also exceeded its SLV at G054 and remains above the SLV downstream at G058 and G057. Mercury exceeds its SLV in C028 by an order of magnitude and in G057 to a lesser degree. G057 had the highest concentration of pentachlorophenol for the reach and the fourth highest concentrations of dioxins/furans. G054 contained chlordane at concentrations exceeding its SLV by an order of magnitude.

G055, G056, and C029, located between the two most contaminated samples (G058 and G054), also indicate SLV exceedances of many of the same constituents. G055 has the highest concentration of lead in this area. With some variability, the PCB concentrations generally appear to decrease from G054 to G058.

Sample/ Contaminant	Dieldrin (ppb)	PCBs (ppb)	DDTs (ppb)	TCDD TEQ(pg/g)	Lead (ppm)	Mercury (ppm)	PCP (ppb)	Chlordane (ppb)
SLV	0.0081	0.39	0.33	0.0091	17	0.07	250	0.37
G058	6.7	49.8	10.5	NA	41.5	0.063	35	1.9
C030 (30 – 99 cm)	ND (0.036)	ND (1.0)	ND (0.13)	0.052	3.31	0.012	4.4	ND (0.52)
G057	ND (0.36)	35.13	2.3	9.95	63.6	0.154	890	3.38
G054	ND (0.18)	260	19.2	3.96	103	0.071	33	6
C028 (30 – 58 cm)	ND (0.036)	47	12.73	3.85	174	0.993	ND (5.2)	1.2
G055	ND (0.26)	63	13.3	NA	306	0.045	ND (4.8)	1.8
G056	0.45	13.2	7.78	5.42	122	0.097	ND (4.0)	1.32
C029 (53 – 157 cm)	ND (0.036)	7.1	2.39	4.13	90.3	1.32	ND (5)	ND (0.2)

Potential Sources: There are stormwater outfalls in this area. G058 is located in the vicinity of City OF 38. Potential sources in the associated drainage basin include historic rail freight depot (1924, 1st at Oak-Burnside), chemical storage (1924, 3rd and Oak), seed storage (1924, Grand and Stark), grain and feed warehouse (1924 – 3rd and Pine), municipal Dock #2 (1924-50 – Washington and Oak); seed warehouse with seed cleaning (1924-50, 1st at Washington-Alder); flour mill (1950, 1st and Washington-Stark); Chas Lilly Grain and Feed warehouse (1950, 3rd and Pine); Fertilizer warehouse (1950, 3rd and Oak); seed warehouse (1950, Grand and Stark).

G054 is located in the immediate vicinity of City OF 36. A highway stormwater outfall (WR-315) is also nearby. The total area drained by these two outfalls extends more than 60 square blocks, beginning as far southeast as SE 11th and Hawthorne and as far north as SE Stark. In addition, the storm sewer that feeds Outfall 36 appears to be fed by at least 7 combined sewer diversions, and an apparent diversion from the Water Street sanitary sewer pump station. Sorting out potential sources will likely require in-pipe sampling.

Recommendation: Analyze archived split of G055 for dioxins/furans which were not analyzed in the original sample. Analyze C029 A and B cores for mercury. Analyze G058 using HR-GCMS to verify detection of pesticides.

5.2.4 Sample G005 and G006 (Figure 11) RM 12.9W

G005 is included in the priority list due to the detection of TBT. PCBs and lead also exceeded SLVs by an order of magnitude at this location. This sample was collected on the west bank along the sea wall and no other samples were collected in the immediate vicinity.

Sample G006 was collected approximately 700 feet upstream of G005 on the west bank at the downstream edge of the Hawthorne Bridge. Samples G007 and C002 were collected approximately 240 feet upstream on the other side of the Hawthorne Bridge. G006 contained concentrations of lead, arsenic, PCBs, DDTs, and Indeno(1,2,3-cd)Pyrene at concentrations exceeding the SLVs by more than a factor of 10. Chlordanes, DDTs, dioxins, PCBs, TBT, and lead exceeded SLVs at C002 and G007.

Sample/Contaminant	TBT (ppb)	Arsenic (ppm)	Lead (ppm)	PCBs (ppb)	Indeno(1,2,3-cd)Pyrene (ppb)	DDTs (ppb)	Chlordanes	TCDD TEQ(pg/g)
SLV	2	7	17	0.39	100	0.33	0.37	0.0091
G006	1.7	126	428	38	1100	4.15	0.94	NA
G007	40	12.7	60.1	150	220	15.55	3.6	3.26
C002 (30 – 85 cm)	7.3	6.02	123	141	66	26.2	4.3	4.13
G005	1700	5.4	197	9.5	64	2.12	0.25	NA

Potential Sources: Potential sources of contamination in this area are ships docked along the sea wall, historical stormwater discharge from the former Harbor Drive, and a historical lumber mill (possibly plywood mill) to the south. Sources of contamination in the vicinity of G006 may be related to ship traffic or discharge from City outfall 08a located in the vicinity of G007/C002.

Recommendations: Collect 3 to 5 surface sediment samples in this area to assess aquatic toxicity. One core sample may be warranted to assess vertical extent. Analytes of potential concern are identified in the table above and may be analyzed if bioassay results indicate potential toxicity.

5.2.5 Sample G048 (Figure 12) RM 13.1E

This sample contained the highest detection of total PCBs in the DPSC area and also had concentrations of total DDTs, dioxins, and chlordanes that exceeded the SLVs by more than a factor of 10. The nearest sample is C025, a deep core collected from 247 to 330 cm below the surface. Samples G047 was collected approximately 300 feet upstream.

Sample/Contaminant	Total PCBs(ppb)	Total DDTs(ppb)	Chlordanes (ppb)	TCDD TEQ(pg/g)
SLV	0.39	0.33	0.37	0.0091
G048	4200	144	4.3	3.12
C025 (247 – 330 cm)	ND (1.0)	ND (0.13)	ND (0.054)	0.006
G047	68	7.14	0.88	NA
G049	43	12.4	1.03	8.8
C026 (30 – 147 cm)	6.5	3.85	0.42	0.75

Potential Sources: There are stormwater outfalls in this area. This sample is located in the vicinity of City OF 33. Potential sources include the Rexall/Taylor Electric Fire (contaminant discharge via stormwater line); historic ironworks (extensive) at Hawthorne Bridge to Water Ave; Holman building.

Recommendations: Analyze archived A (0 - 30 cm) and B (30 – 142 cm) cores from C025 for the contaminants of concern identified in the above table. A sample grid, consisting of 10 surface grab samples and cores, is recommended in this area as part of a more focused investigation to determine the need for and scope of a remedial action. Details on the sample locations, core depths, and intervals to be analyzed will be provided in a scope of work.

5.2.6 Sample G045 (Figure 13) RM 13.3E

This sample is located on the east side of the river in the vicinity of the Marquam Bridge and was the third highest ranked sample based on toxicity only. It contained concentrations of PCBs, DDT, naphthalene exceeding the SLVs, and the second highest TCDD TEQ of the reach. Core sample C024 was collected nearby and samples G044 and C023 were collected approximately 200 feet upstream on the other side of the Marquam Bridge.

Sample/Contaminant	PCBs (ppb)	DDTs (ppb)	Naphthalene (ppb)	TCDD TEQ (pg/g)
SLV	0.39	0.33	561	0.0091
G045	62	7.48	3400	15.02
C024 (99 – 142 cm)	ND (1.0)	ND (0.2)	290	0.011
G044	17	1.056	140	8.12
C023 (31 – 80 cm)	ND (1.0)	ND (0.13)	740	0.05

Potential sources: Possible sources may be associated with stormwater outfalls WR321, WR448, and City OF 32 which is near G045. An older abandoned city stormwater outfall also discharged in this location. Both drained land at PGE Station L. Other sources in this area include the existing PGE transformer substation just east of OMSI, a former rail line east of OMSI that leads to an old

Portland Railway repair shop; the former Inman-Poulson Lumber Mill (operated 1909 – 1950); and East Side Plating Plant #4. The storm sewer line extends to the former location of Portland Railway Light and Power Company's Power Station F, a power generating plant located somewhat south of PGE Station L that was probably fired by wood wastes from Inman-Poulson. The older abandoned city storm sewer had manholes on the PGE substation lot, just east of OMSI, as well as along the railroad right of way, and received discharge from East Side Plating Plant #4 (at SE 3rd and Stephens). East Side Plating Plant #4 (still in operation) is in the cleanup program data base (ECSI) because of historic plating waste discharges to sewers, which might have included PCBs if the plant ever had a fire or leaking transformers/capacitors.

Recommendations: Analyze archived surface sample G046 and the B core from C024 for analytes of potential concern identified in the above table. Collect a sample in this area for bioassay analysis. Analytes of potential concern are identified in the table above and may be analyzed if bioassay results indicate potential toxicity. Collect a sample at OF WR-448 if feasible, to assess as a potential source.

5.2.7 Samples C022/G041 (Figure 14) RM 13.5E

Sample C022, a core collected from 96 to 156 cm below the surface, was identified as one of the top 8 with respect to cumulative HI ratio and G041 was in the subsequent set of 6. Samples G039 and G040 are between 300 and 400 feet upstream. Again the potential risk is driven primarily by total PCBs with notable contribution from total DDTs. The concentration of mercury at G041 exceeded the SLV by an order of magnitude. CO22 had the highest detection of TCDD in the downtown reach.

Sample/Contaminant	Total PCBs (ppb)	Total DDTs (ppb)	Mercury (ppm)	Total chlordanes (ppb)	TCDD TEQ(pg/g)
SLV	0.39	0.33	0.07	0.37	0.0091
C022 (96 – 156 cm)	610	70.6	0.231	14	8.81
G041	133.5	10.89	0.7125	2.9	6.39
G039	10.1	1.28	0.05	0.46	NA
G040	ND (1.0)	ND (0.13)	0.015	ND (0.054)	NA

Potential Sources: Possible sources of contamination in this area include runoff from a PGE storage lot, PGE Stations L and F, the former Inman-Poulsen Lumber yard, and railroad warehousing further to the east. Figure 15 shows the historical locations of these facilities.

Recommendations: Analyze archived B (30 – 96 cm) core from C022 location for the analytes identified as elevated in the above table. A sample grid is recommended in this area as part of a more focused investigation to define the magnitude and extend of contamination. Six grab samples and cores should be collected up and downstream and toward the channel from C022/G041 in the slight embayment area at this location. Cores are warranted to assess the vertical extent and should be extended to below the depth of C022. Shoreline sampling to assess the potential source of contamination may also be of value at this time. Specific locations and core depths to be sampled will be provided in a scope of work.

5.2.8 Sample G017/C039 area (Figure 16) RM 14.1W

The HI ranking of sample G017 was due to PCBs which were detected at 520 ppb. Total DDTs (70.3 ppb) exceeded the SLV by a factor of 100, and chlordanes (15 ppb) by a factor of 10. The closest sample to this one is a core sample (C008). Core samples were also collected 120 feet downstream at C036; and at C037 collected approximately 200 feet upstream. Slightly further downstream are core samples C007 and C035 and surface sediment sample G016. Sample C007 had the third highest TCDD TEQ for the reach. Zidell collected two samples in this area as part of their investigation (WRS-1 and WRS-46); PCBs were not detected in these samples but detection limits were 150 ppb or higher.

The sample of concern at C039 is the deeper (60 – 120 cm) of 2 cores analyzed from this location. PCBs are the primary driver at 538 ppb; DDTs also exceeded the SLV by an order of magnitude. Two additional cores (C038 and C009) and one surface sediment sample (G018) were also collected in this area.

Sample/Contaminant	Total PCBs (ppb)	Total DDTs (ppb)	Lead (ppm)	Total chlordanes (ppb)	TCDD TEQ (pg/g)
SLV	0.39	0.33	17	0.37	0.0091
G017	520	70.3	57.5	15	0.95
C008 (30 – 130 cm)	62	8.24	23.5	1.62	3.69
C036 (0 – 60 cm)	51	6.81	83	ND (1.5)	NA
C036 (60 – 68 cm)	24	3.8	49	ND (0.23)	NA
C037 (0 – 60 cm)	75	10.35	33	1.9	NA
C037 (60 – 68 cm)	26	3.29	14.9	1.3	NA
C007 (88 – 210 cm)	21	8.8	17.8	0.57	12.75
G016	60	8.2	40.5	2.2	1.58
C035 (0 – 61 cm)	41	11.4	51.4	1.6	NA
C039 (60 – 120 cm)	538	7.17	11.52	ND (0.98)	NA
C039 (0 – 60 cm)	46	1.05	16.1	ND (0.9)	NA
C038 (0 – 60 cm)	ND (1.0)	ND (0.13)	30.15	ND (0.22)	NA
C038 (60 – 120 cm)	ND (1.0)	0.13	14.4	ND (0.22)	NA
C009 (30 - 182 cm)	19.6	4.09	9.62	0.47	1.17
G018	39	4.58	102	1.49	2.28

Potential Sources: Possible sources include runoff associated with altered drainage and disturbed soil at a shoreline site historically used for ship building and other manufacturing activities.

Recommendation: Analyze the archived C (130 – 362 cm) core from the C008 location for contaminants of potential concern identified in the above table. Analyze archived samples G076, C007A, C035A, and C036A for dioxins/furans. Also, analyze C007A for PCBs and pesticides. Finally, confirm the presence of pesticides in G017 by high resolution gas chromatography mass spectroscopy.

Collect surface sediment samples in the vicinity of the C037 and C036 locations to enhance data set for evaluating vertical and lateral extent in this area. Three grab samples located east of samples G017, C037, and C039, with a core at the location out from C039 would help to assess lateral extent of contamination in this area.

5.2.9 Sample G030 (Figure 17) RM 15.1E

PCBs, DDTs, and lead are the risk drivers for this sample location. G030 had the highest TCDD TEQ and highest Chlordane concentration in this reach. Core sample C018 was also collected in this area.

Sample/Contaminant	Total PCBs (ppb)	Total DDTs (ppb)	Chlordane (ppb)	Lead (ppm)	TCDD TEQ (pg/g)
SLV	0.39	0.33	0.37	17	0.0091
G030	710	40.7	15.9	389	19.22
C018 (30 – 122 cm)	ND (7.4)	0.89	0.12	13.3	0.47

Potential Sources: Combined sewer overflows discharge from City OF 28 in this area. Possible sources include industry along the east edge of UPRR Brooklyn Yard, and former Hollywood Lights/historic heavy equipment manufacturing at 20th and Insley.

Recommendations: The detections at this location appear to be tied to the sewer outfall. Up the pipe sampling will likely be appropriate as part of source identification. DEQ recommends collection of three surface sediment samples up and downstream of the outfall and one core at the downstream location to assess general extent of contamination. Collect three surface sediment samples and one core sample to better delineate the extent of these contaminants.

5.3 Second Tier Priority Locations

These locations will be further evaluated after initial work is completed to assess top priority areas.

6.0 Summary

As indicated above, a mix of recommended follow-up actions is recommended based on available information for each of the 9 areas described above. This ranges from confirming detections and follow-up source identification actions as suggested for the Sample G030 area to more intensive characterization of releases as recommended for the G048 area. Because the analysis of archived samples can be completed relatively quickly and may provide data that would help to guide the field sampling effort, archived samples will be analyzed as a first phase and the results considered before finalizing the work plan for the field sampling effort. A major aspect of the follow-up actions will be to identify likely sources, ensure there are not continuing releases, and, where appropriate, engage responsible parties in any additional investigation and cleanup of the contaminated sediment that is warranted. All recommendations are summarized in Table 5.

References

GSI, 2009 Field and Data Report Downtown Portland Sediment Characterization, Volumes 1 – 3, GSI Water Solutions, Inc. January 2009.

Integral, 2007 Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report, prepared for the Lower Willamette Group, Integral Consulting, Inc.; Windward Environmental LLC, Kennedy/Jenks consultants, and Anchor Environmental, February 2007.

Lower Willamette Group, 2005 Portland Harbor RI/FS – Round 2A Sediment Site Characterization Summary Report, July 15, 2005.

MFA, 2007 Supplemental Sediment Assessment Report, Zidell Waterfront Property, Maul Foster & Alongi, November 2007.

ODEQ, 2007 Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment, Oregon Department of Environmental Quality, April 2007.

ODEQ, 2005   Portland Harbor Joint Source Control Strategy, Oregon Department of Environmental Quality, December 2005.

Table1 - General Comparisons
Downtown Willamette and Portland Harbor Concentrations
Select Contaminants of Concern

Summary Statistics for Surface Sediment Samples

Analyte	Downtown: Number Analyzed	Downtown: Number Detected	Downtown: Percent Detected	Downtown: Detected Concentrations Minimum	Downtown: Detected Concentrations Maximum	Downtown: Mean	Downtown: Percentile detects and non 95th	Portland Harbor[1]: Number Analyzed	Portland Harbor[1]: Number Detected	Portland Harbor[1]: Percent Detected	Portland Harbor[1]: Detected Concentratio Minimum	Portland Harbor[1]: Detected Concentratio Maximum	Portland Harbor[1]: Mean	Portland Harbor[1]: Percentile detects and nc 95th
PCB Aroclors														
Total Aroclors ug/kg	91	65	71	1.3	4200	91.4	171	520	423	81.3	0.851	27,400	216	679
Butytins														
Tributyltin ion ug/kg	81	30	37	0.66	1700.335	23.78	28	116	115	99.1	0.45	46,000	608	150
Dioxins/Furans														
Dioxin/furan TCDD toxicity equivalent pg/g	48	45	94	0.011	19.2	2.54	9.95	76	76	100	0.00684	322	12.6	37.4
Metals														
Arsenic mg/kg	91	91	100	1.19	126	4.75	5.4	562	562	100	0.97	34	4.16	7.99
Lead mg/kg	91	91	100	2.93	428	48.28	130	562	562	100	2.5	1290	28.9	67.4
Mercury mg/kg	91	91	100	0.007	4.06	0.14	0.431	562	556	98.9	0.006	2.01	0.0907	0.235
PAHs														
Acenaphthene ug/kg	91	73	80	0.27	1900	34.99	48	562	538	95.7	0.22	600,000	3530	2700
Indeno(1,2,3-cd)pyrene ug/kg	91	83	91	0.22	2300	81.91	150	562	551	98	0.95	210,000	2150	3300
Naphthalene ug/kg	91	86	95	0.57	5300	116.41	130	562	375	55.7	2.8	1,500,000	5380	520
Pesticides														
Total DDx ug/kg	91	82	90	0.047	144	7.99	19.2	508	495	97.4	0.051	15,300	123	206
Dieldrin ug/kg	91	11	12	0.042	6.7	0.20	0.35	503	124	24.7	0.068	356	3.81	0.869U
Total Chlordanes ug/kg	91	70	77	0.039	15.9	1.24	4.1	508	417	82.1	0.042	669	6.14	8.07
Phenols														
Pentachlorophenol ug/kg	91	12	13	3.2	890	18.91	35	562	75	13.3	0.81	320	27.4	16

Summary Statistics for Subsurface Sediment Sample:

Analyte	Downtown: Number Analyzed	Downtown: Number Detected	Downtown: Percent Detected	Downtown: Detected Concentrations Minimum	Downtown: Detected Concentrations Maximum	Downtown: Mean	Downtown: Percentile detects and non 95th	Portland Harbor: Number Analyzed	Portland Harbor: Number Detected	Portland Harbor: Percent Detected	Portland Harbor: Detected Concentratio Minimum	Portland Harbor: Detected Concentratio Maximum	Portland Harbor: Mean	Portland Harbor: Percentile detects and nc 95th
PCB Aroclors														
Total Aroclors ug/kg	65	29	45	1.6	610	38.3	141	461	289	62.7	0.906	21,900	390	755
Butytins														
Tributyltin ion ug/kg	42	8	19	0.55	23	0.90	1.4	171	103	60.2	0.32	36,000	752	550
Dioxins/Furans														
Dioxin/furan TCDD toxicity equivalent pg/g	30	28	93	0.006	12.8	2.98	6.02	119	107	89.9	0.00053	200	8.46	37
Metals														
Arsenic mg/kg	65	65	100	0.8	7.18	2.86	5.09	510	510	100	0.8	44.5	4.36	7.62
Lead mg/kg	65	65	100	1.36	371	42.75	174	510	510	100	2.06	3330	38.5	87.2
Mercury mg/kg	65	65	100	0.009	3.46	0.28	1.32	510	489	95.9	0.007	4.14	0.191	0.575
PAHs														
Acenaphthene ug/kg	65	55	85	0.33	8100	221.67	470	511	472	92.4	0.19	3,900,000	24,000	28,000
Indeno(1,2,3-cd)pyrene ug/kg	65	49	75	0.28	2400	100.24	470	511	482	94.3	0.29	610,000	7020	18,000
Naphthalene ug/kg	66	47	71	0.45	5400	159.89	530	555	391	70.5	0.5	20,000,000	197,000	21,000
Pesticides														
Total DDx ug/kg	65	40	62	0.052	301	10.2	30.5	444	379	85.4	0.08	72,700	519	609
Dieldrin ug/kg	65	2	3	0.29	7.45	0.31	0.5	444	9	2.03	0.303	51	9.52	0.937U
Total Chlordanes ug/kg	65	34	52	0.12	14	1.15	4.3	444	279	62.8	0.038	2330	24.3	36.1
Phenols														
Pentachlorophenol ug/kg	53	3	6	0.24	26	2.10	3.15	511	169	33.1	1	5600	56.3	16

[1] Portland Harbor RI/FS Round 2A Sediment Site
Characterization Summary Report, July 15, 2005

Table 2 - Analytes Evaluated and Screening Levels

Analyte_Group	Analyte	Bioaccumulation Screening Level	Toxicity Screening Level	Units
Aroclors	Total PCBs	0.39	676	ug/kg
Butyltins	Tributyltin ion	2		ug/kg
Metals	Antimony		64	mg/kg
Metals	Arsenic	7	33	mg/kg
Metals	Cadmium	1	4.9	mg/kg
Metals	Chromium		111	mg/kg
Metals	Copper		149	mg/kg
Metals	Lead	17	128	mg/kg
Metals	Mercury	0.07	1	mg/kg
Metals	Nickel		48.6	mg/kg
Metals	Selenium	2	5	mg/kg
Metals	Silver		5	mg/kg
Metals	Zinc		459	mg/kg
PAHs	2-Methylnaphthalene		200	ug/kg
PAHs	Acenaphthene		200	ug/kg
PAHs	Acenaphthylene		300	ug/kg
PAHs	Anthracene		845	ug/kg
PAHs	Benzo(a)anthracene		1050	ug/kg
PAHs	Benzo(a)pyrene		1450	ug/kg
PAHs	Benzo(g,h,i)perylene		300	ug/kg
PAHs	Benzo(k)fluoranthene		13000	ug/kg
PAHs	Chrysene		1290	ug/kg
PAHs	Dibenzo(a,h)anthracene		1300	ug/kg
PAHs	Fluoranthene		2230	ug/kg
PAHs	Fluorene		536	ug/kg
PAHs	Indeno(1,2,3-cd)pyrene		100	ug/kg
PAHs	Naphthalene		561	ug/kg
PAHs	Phenanthrene		1170	ug/kg
PAHs	Pyrene		1520	ug/kg
Pesticides	Total DDTs	0.33	28	ug/kg
Pesticides	Aldrin		40	ug/kg
Pesticides	Dieldrin	0.0081	61.8	ug/kg
Pesticides	Endrin		207	ug/kg
Pesticides	Heptachlor		10	ug/kg
Pesticides	Heptachlor epoxide		16	ug/kg
Pesticides	Total Chlordanes	0.37	17.6	ug/kg
Phenols	Phenol		50	ug/kg
Phenols	Pentachlorophenol	250	1000	ug/kg
Phthalates	Bis(2-ethylhexyl) phthalate		330	ug/kg
Phthalates	Diethyl phthalate		600	ug/kg
SVOCs	1,2,4-Trichlorobenzene		9200	ug/kg
SVOCs	1,2-Dichlorobenzene		1700	ug/kg
SVOCs	1,3-Dichlorobenzene		300	ug/kg
SVOCs	1,4-Dichlorobenzene		300	ug/kg
SVOCs	Carbazole		1600	ug/kg
SVOCs	Hexachlorobenzene		19	ug/kg
SVOCs	Hexachlorobutadiene		600	ug/kg
SVOCs	Hexachlorocyclopentadiene		400	ug/kg
dioxins	TCDD	0.0091	9	pg/g

Source: Portland Harbor Joint Source Control Strategy, ODEQ 2005

Soil/Stormwater Sediment Pathway

Table 3 Overall HI Ratio Sum/Sample Location

Sample Location	Ratio Sum
G048	11231.80
C031	2500.63
G030	2017.99
C022	1825.03
G017	1592.85
C039	1404.31
G058	1000.12
G005	897.68
G054	760.72
G007	482.12
G036	476.29
C002	472.53
C021	411.80
G041	399.73
G015	391.48
C019	260.65
G062	245.06
C037	233.37
G055	232.58
C004	231.00
G070	210.80
G047	203.60
G045	202.60
G037	202.60
G011	201.03
G012	197.79
C008	193.66
G016	189.14
G014	188.76
G006	188.19
G059	186.96
G049	168.18
C028	166.62
C035	163.36
C027	162.12
C036	161.01
G020	144.84
G009	133.31
G003	132.97
G056	131.34
G018	125.91
C039	124.34
G027	118.27
G013	114.08

Sample Location	Ratio Sum
G038	107.07
C037	104.89
C020	96.43
G065	95.06
C007	92.77
C006	91.31
C005	91.05
G021	88.27
G001	82.09
C036	78.88
C035	77.90
G085	70.61
G064	68.79
C009	68.00
G010	67.54
G052	67.48
G057	61.46
G060	59.58
G046	58.52
C029	58.13
C034	57.86
G008	56.10
G044	56.08
G019	53.50
C034	46.92
C010	46.22
G023	45.10
C016	43.84
C026	36.43
G039	36.26
G061	32.93
G053	32.25
G026	30.21
G063	27.42
C017	27.29
C001	25.56
G025	25.35
G002	23.42
G035	22.09
G051	21.00
G080	20.28
G050	19.34
G031	18.69

Sample Location	Ratio Sum
G024	18.23
C032	18.02
G043	17.73
C023	17.61
G073	16.50
C014	15.07
C024	12.89
G029	10.91
C025	8.81
C038	8.15
G075	7.37
C018	6.72
G032	5.84
G028	5.66
G066	4.20
C003	3.81
G022	3.73
C011	2.98
G076	2.74
G072	2.01
G033	1.90
G079	1.78
G078	1.78
G074	1.74
G068	1.57
G040	1.56
C033	1.24
G077	1.23
C030	1.20
G069	1.13
G071	1.02

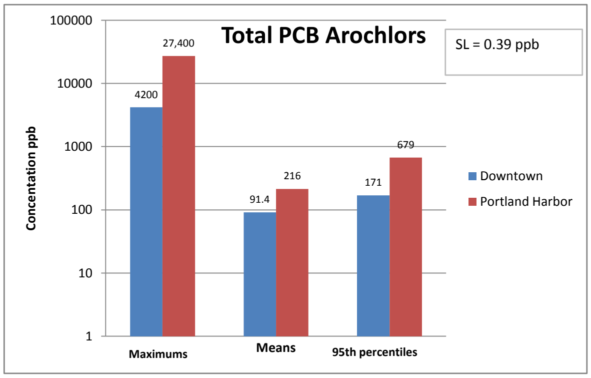
Top 9 values
Second tier

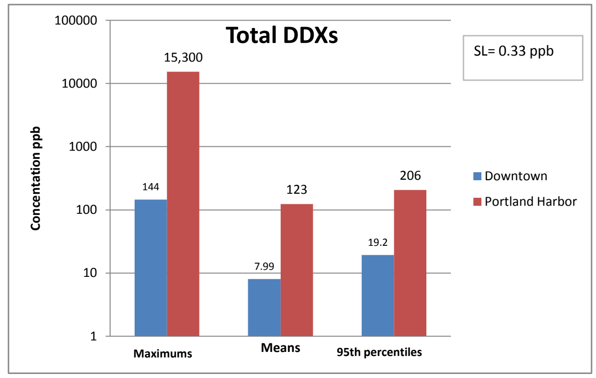
Table 4 Toxicity HI Sum/Sample Location
Toxicity Screen only

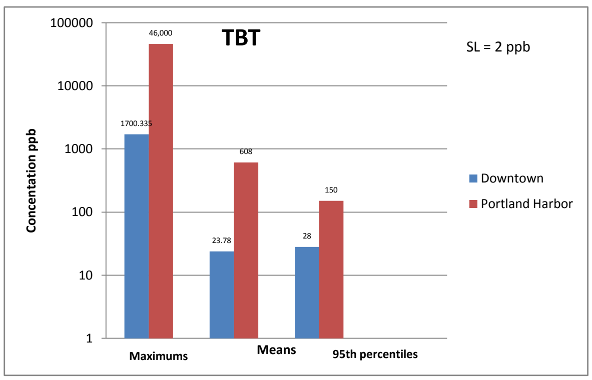
Sample Location	Ratio Sum	Sample Location	Ratio Sum	Sample Location	Ratio Sum
G003	161.57	G052	7.73	G039	4.22
G006	89.54	C005	7.52	G023	4.18
G045	40.95	G037	7.20	G051	4.17
C020	28.06	G011	7.07	G050	4.14
G048	27.92	G063	7.05	G029	4.03
C035	27.84	G013	7.04	G010	3.97
G054	25.75	C027	6.94	G025	3.95
G007	25.70	C003	6.91	G024	3.89
C031	23.41	C007	6.85	C014	3.88
G030	23.15	C034	6.81	C039	3.83
C029	22.78	G038	6.76	G019	3.74
C001	22.25	G008	6.72	G066	3.51
G049	18.08	G065	6.63	G026	3.49
C019	17.00	C035	6.54	G028	3.46
C028	16.32	C016	6.53	G022	3.38
C032	15.69	G009	6.48	G031	3.27
C002	14.29	C025	6.25	C011	3.23
G056	13.24	C004	6.18	G032	3.23
G059	12.93	G062	5.95	G075	3.02
C022	12.09	G061	5.93	G067	2.89
G055	11.89	C037	5.89	G076	2.79
C021	11.61	G044	5.85	C018	2.62
C024	11.50	G014	5.72	G079	2.51
G036	11.42	C008	5.64	G040	2.34
G002	11.29	C017	5.58	G072	2.30
G060	11.26	G043	5.53	G035	2.24
G005	11.07	G012	5.47	G074	2.20
G027	10.86	G018	5.46	G068	2.20
G058	10.31	C036	5.18	G073	2.11
G021	10.22	C037	5.09	C030	2.03
C023	9.84	G070	4.92	C033	2.02
G046	9.55	C009	4.74	G078	1.95
G064	8.74	C039	4.73	G033	1.88
C010	8.52	C038	4.71	G077	1.79
G041	8.49	C038	4.55	G069	1.59
G017	8.17	G080	4.54	G071	1.48
G057	8.03	C034	4.48		
G015	7.92	G047	4.45		Top 3 values
C036	7.87	G085	4.42		
G020	7.87	G053	4.40		
G001	7.76	C026	4.34		
C006	7.76	G016	4.32		

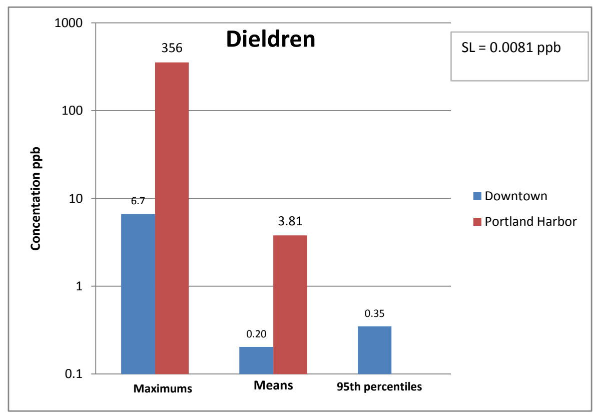
Table 5	Downtown Willamette Follow-up Sampling Recommendations		
Sample Location	COCs	Archived samples to analyze	Additional Samples to collect
C031	DDTs, dieldren, PCBs	A and B Cores, confirm	one surface grab and one core at OF 40
RM 12.1E	lead, chlordanes,	pesticides in C031-C by	one surface grab and one core at OF 309
	dioxin	HR-GCMS	
G003	Hg, PAHs		Representative surface sample for bioassay.
RM 12.4W			
G058/G054	dieldren, PCBs, DDTs	G055 (dioxin only), C029-A	
RM 12.5E	dioxin, lead, mercury,	and B (mercury), confirm	
	PCP, chlordane	pesticides in G054, G058	
G005/G006	TBT, PCBs, lead,		Consider sea wall area one area of potential
RM 12.9W	arsenic, PAHs, DDTs,		concern for aquatic toxicity. Identify 5
	chlordanes, dioxin		locations for collection of surface sediment
			samples for chemistry and bioassay analysis.
			Attempt cores based on field observations of
			significant contamination at depth and inability
			to collect cores in first round
G048	PCBs, DDTs,	A and B cores from C025	Special evaluation area
RM 13.1E	chlordanes, dioxin		surface grabs and cores - 3 X 3 grid (9 locations)
			between C026 and G047 and one sample at OF33
G045	PCBs, DDTs, PAHs	G046 and the B core from	1 sample for bioassay anal
RM 13.3E	dioxin	C024	1 surface grab at OF WR-448 if feasible
C022/G041	PCBs, DDT, mercury,	B core from C022	Special evaluation area
RM 13.5E	lead, chlordanes,		surface grabs and cores - grid of 6 locations
	dioxin		in slight embayment area
G017/C039	PCBs, DDT, chlordanes	C core from C008	3 surface sediment samples out from G017 to
RM 14.1W	dioxin, lead	confirm pesticides in G017	define lateral extent and core riverward of C039
		by HR-GCMS	
		G076, C007A, C035A, and	
		C036A for dioxins/furans	
		C007A for PCBs and pesticides	
G030	PCBs, DDTs, lead	A core from C018	3 grab or composite samples
RM 15.1E	dioxin, chlordanes		up/down and toward channel
			One core sample
Totals		22	53

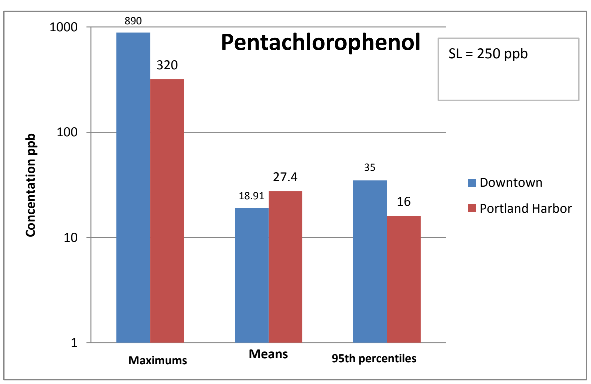
Figure 1 page 1 of 3 - General Comparisons
Downtown Willamette and Portland Harbor Concentrations
Select Contaminants of Concern - Surface Concentrations











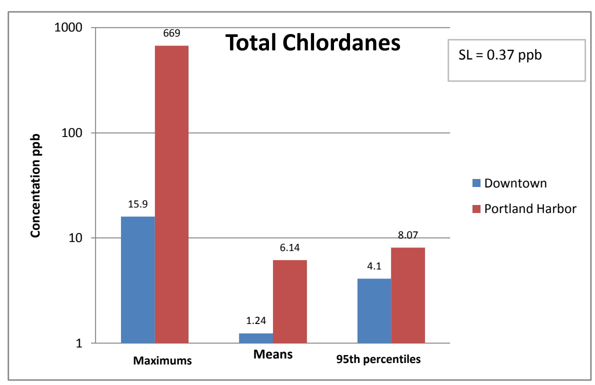
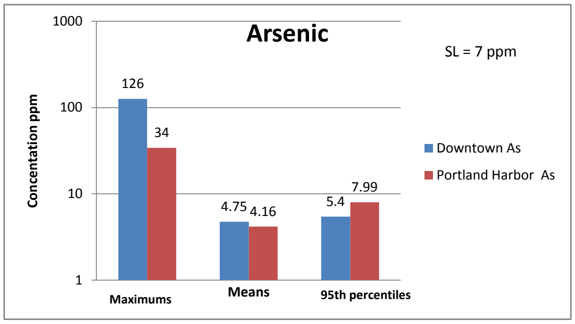
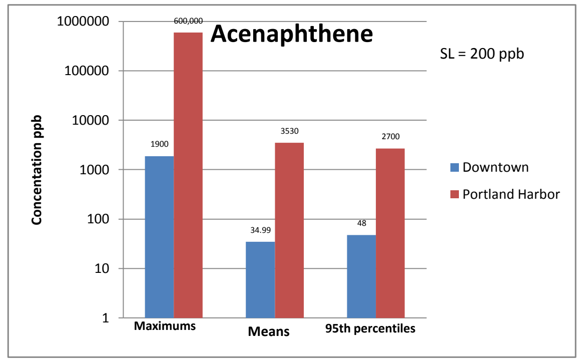
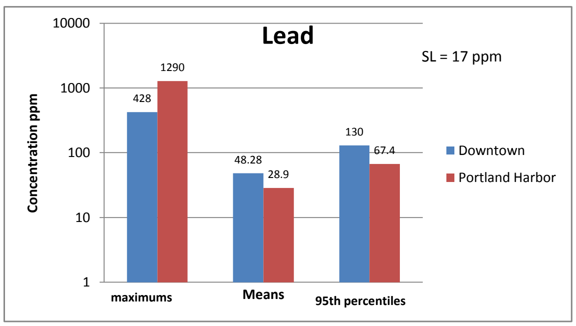
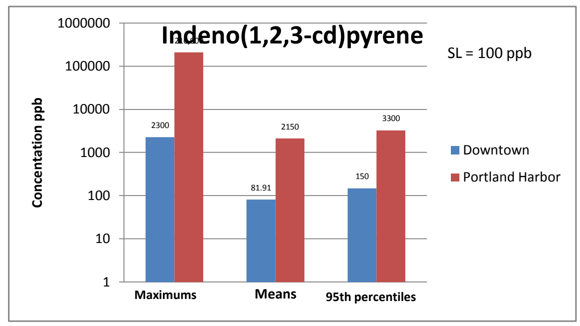


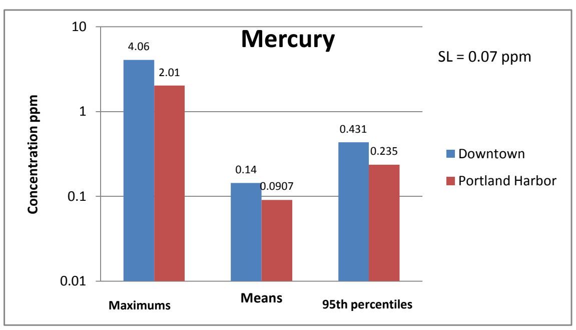
Figure 1 page 2 of 3 - General Comparisons
Downtown Willamette and Portland Harbor Concentrations
Select Contaminants of Concern - Surface Concentrations











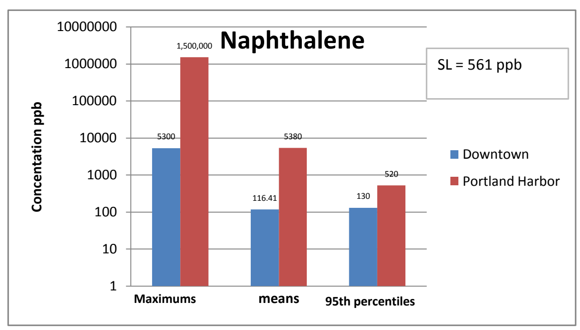


Figure 1 page 3 of 3 - General Comparisons

Downtown Willamette and Portland Harbor Concentrations

Select Contaminants of Concern - Surface Concentrations

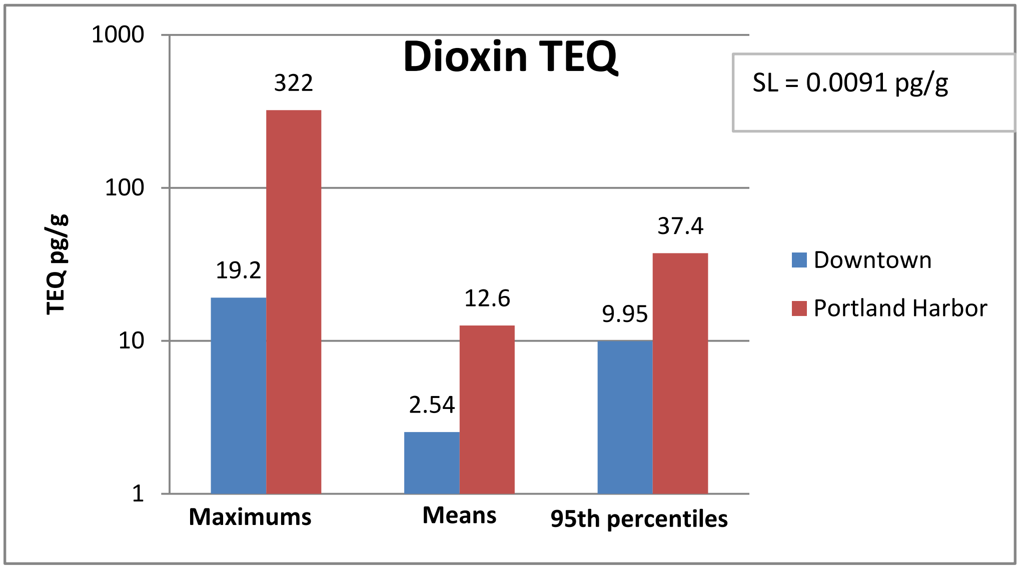
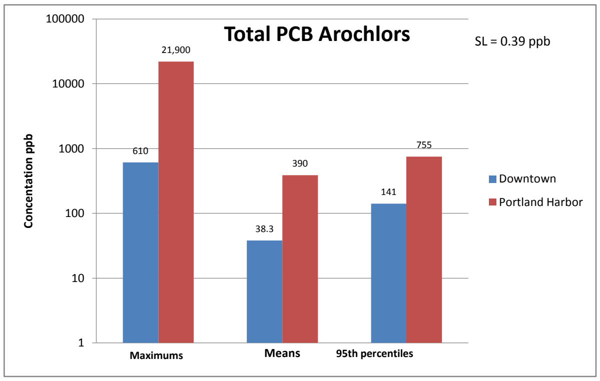
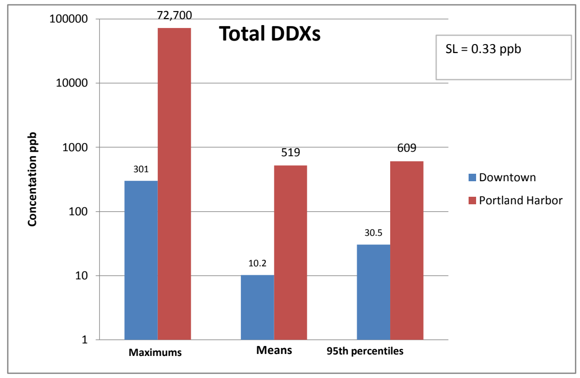
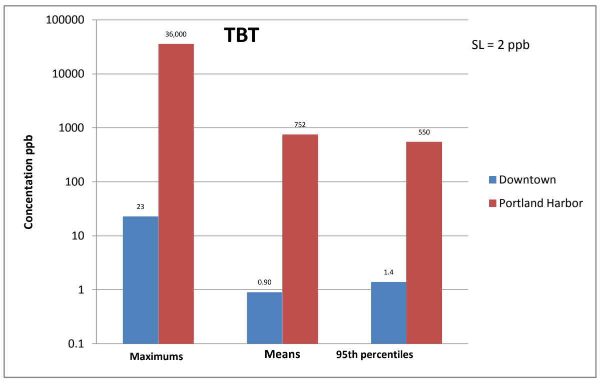
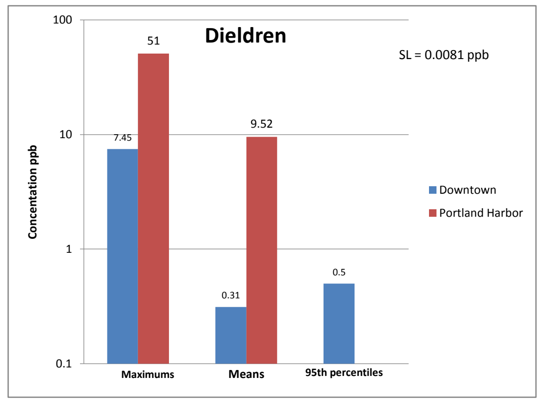


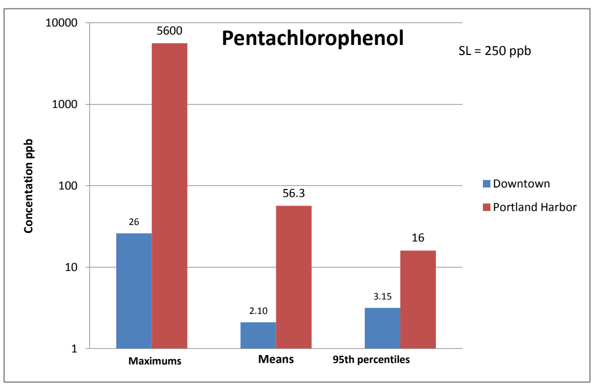
Figure 2 page 1 of 3 - General Comparisons
Downtown Willamette and Portland Harbor Concentrations
Select Contaminants of Concern - Subsurface Concentrations











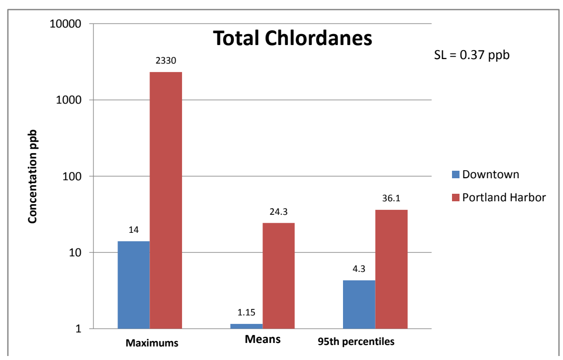
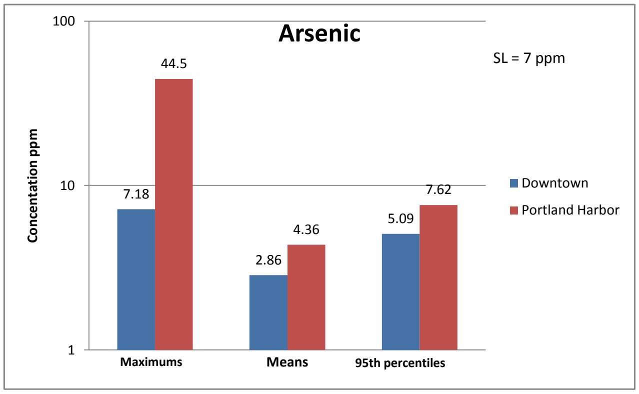
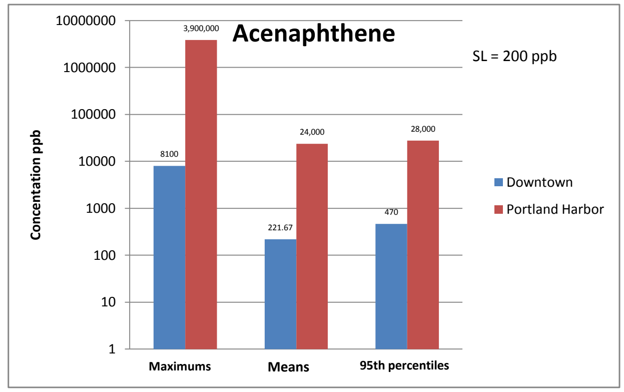
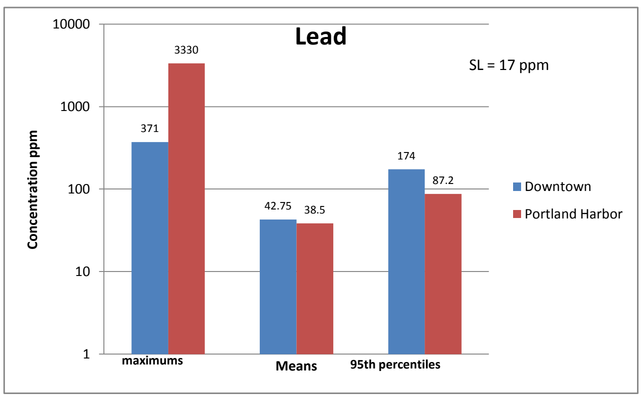
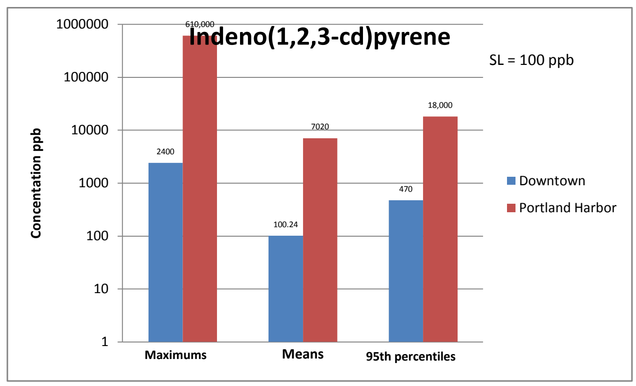


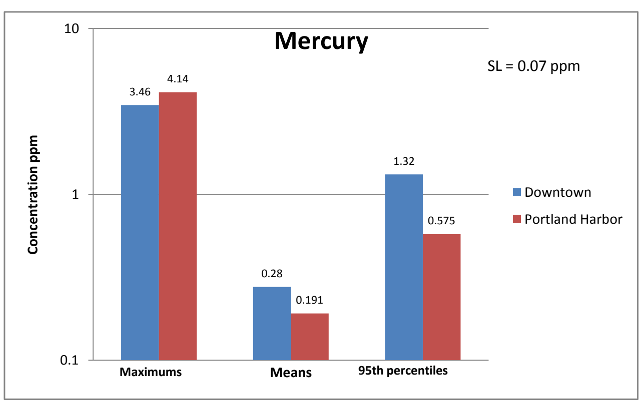
Figure 2 page 2 of 3 - General Comparisons
Downtown Willamette and Portland Harbor Concentrations
Select Contaminants of Concern - Subsurface Concentrations











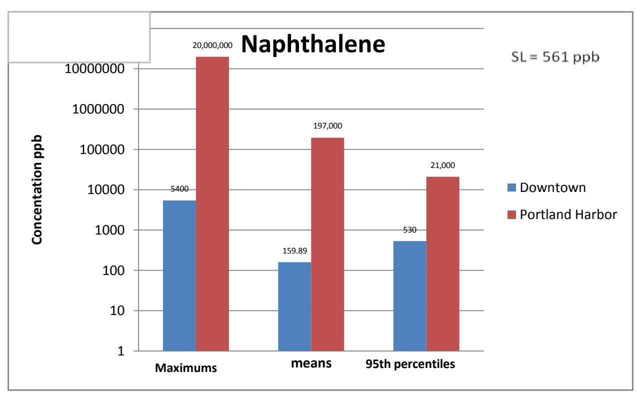


Figure 2 page 3 of 3 - General Comparisons
Downtown Willamette and Portland Harbor Concentrations
Select Contaminants of Concern - Subsurface Concentrations

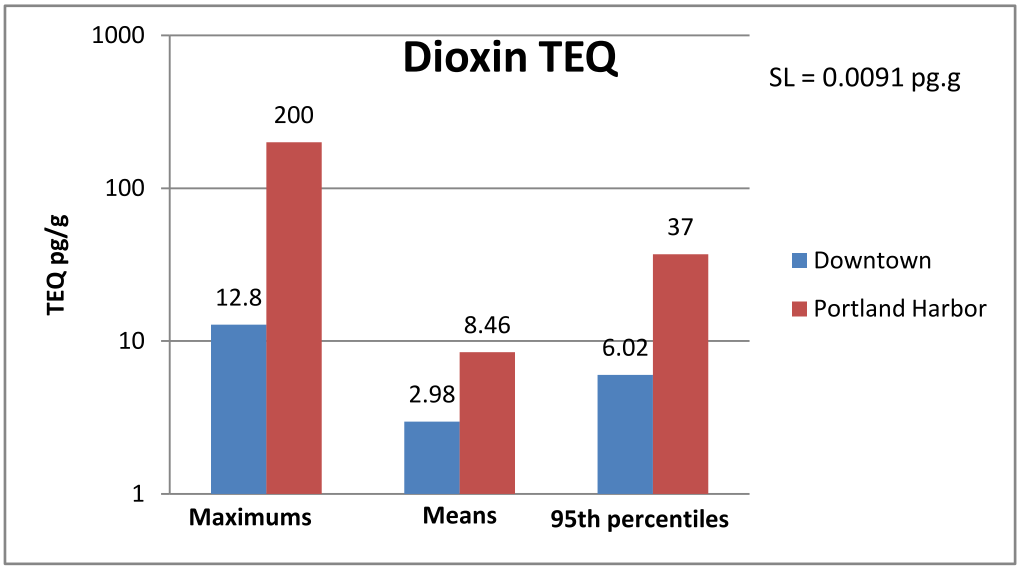


Figure 3 - HI Sum Plot

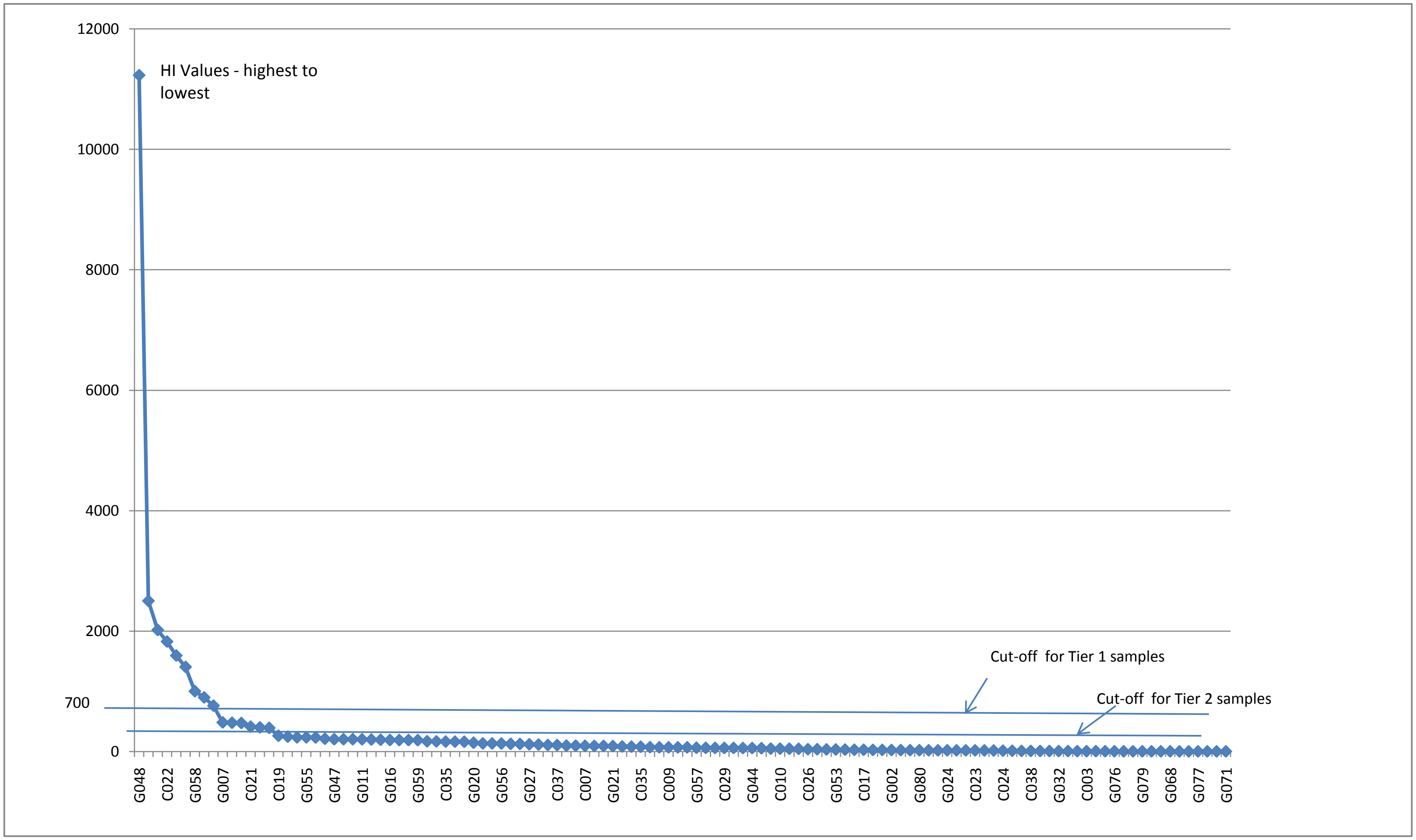


Figure 4 - Downtown Willamette
Top 9 Priority Locations
Bioaccumulation and toxicity risk

Figure 5 Downtown Willamette
Tier 2 Locations
Bioaccumulation and toxicity risk

Figure 6 - HI Sum Plot - Toxicity Screen Only

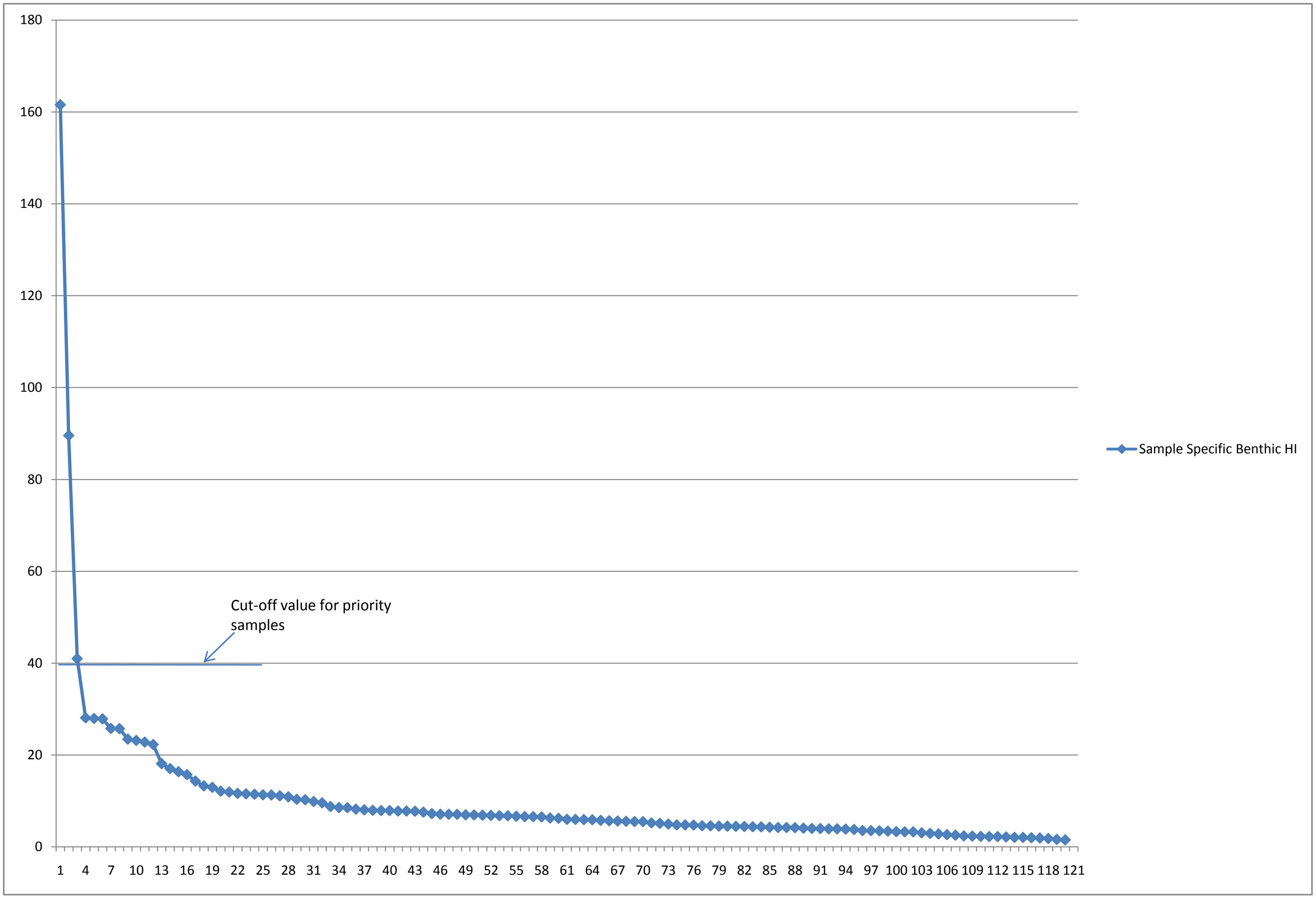


Figure 7 Downtown Willamette Toxicity Screen Priority Locations

Figure 8 Downtown Willamette River Mile 12.1E - Sample C031 Area

Figure 9 Downtown Willamette River Mile 12.4W - Sample G003 Area

Figure 10 Downtown Willamette River Mile 12.5E - Samples G058/G054 Area

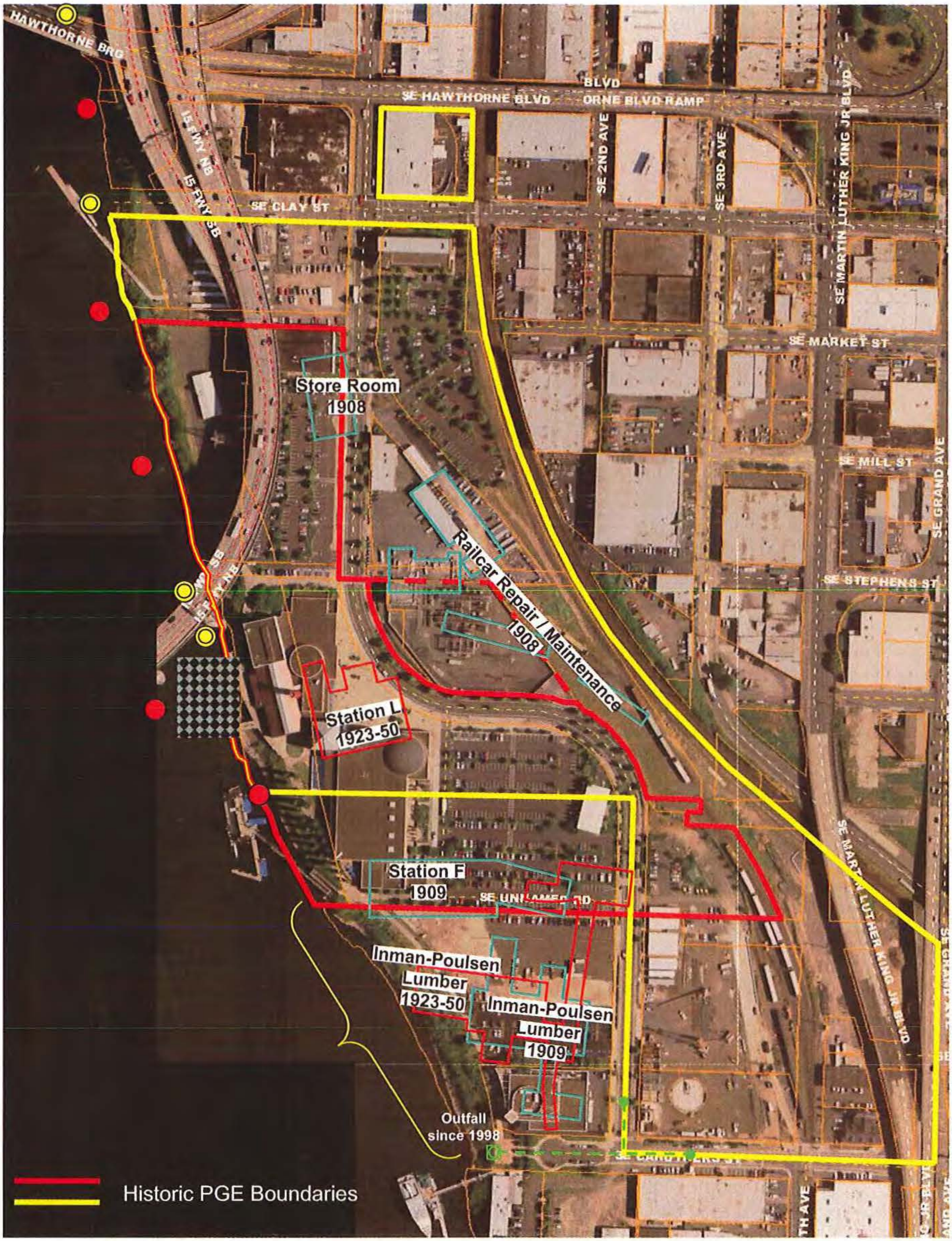
Figure 11 Downtown Willamette River Mile 12.9W - Samples G005/G006 Area

Figure 12 Downtown Willamette River Mile 13.1E - Sample G048 Area

Figure 13 Downtown Willamette River Mile 13.3E - Sample G045 Area

Figure 14 Downtown Willamette River Mile 13.5E - Samples C022/G041 Area

Figure 15 Downtown Willamette RM 13.5E



Willamette River East Bank near OMSI

Figure 15 Legend

Approximate extent of PEG-controlled properties in 1950

Approximate extent of PGE-controlled properties in 1909

Sources: Sanborne Fire Insurance Maps (Oregon State Library) for the years 1950 (Maps 739, 740, 753, 754, 765, 766, 777) and 1924 (Maps 739, 740, 753, 754, 765, 766, 777), projected onto a 2006 Aerial photo of SE Portland from Portlandmaps.com.

Figure 16 Downtown Willamette River Mile 14.1W - Samples G017/C039 Area

Figure 17 Downtown Willamette River Mile 15.1E - Sample G030 Area